PROJECT facts

U.S. DEPARTMENT OF ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

Sequestration

10/2002

GREENHOUSE GAS EMISSIONS CONTROL BY OXYGEN FIRING IN CIRCULATING FLUIDIZED BED BOILERS

PRIMARY PARTNER

Alstom Power Inc.
ABB Lummus Global, Inc.
Praxair, Inc.
Parsons Energy and Chemical Group

TOTAL ESTIMATED COST

Total	$1,996,486
DOE	$1,597,189
Non-DOE	$ 399,297

CUSTOMER SERVICE

800-553-7681

WEBSITE

www.netl.doe.gov

Background

The object of oxygen-fired combustion is to burn the fuel in enriched air or pure oxygen to produce a concentrated stream of CO_2. Oxygen fired combustion presents significant challenges, but also provides a high potential for technology breakthroughs and a step-change reduction in CO_2 separation and capture costs. Barriers and issues include: 1) oxygen from cryogenic air separation is expensive, and oxygen combustion consumes several times more oxygen than gasification; 2) combustion of fuels in pure oxygen occurs at temperatures too high for existing boiler or turbine materials, while CO_2 recycle to control temperature increases the parasitic power load.

Development and costing of an optimized oxygen fired combustion scheme requires an engineering study to identify and resolve the technical issues related to application of oxygen firing with flue gas recycle to a boiler and its associated process heaters. Alstom Power has proposed a two-case approach in which evaluations would analyze both fossil fuel (coal and petroleum coke) based and biomass based circulating fluidized bed (CFB) for power production. The first case will be to identify and analyze normal baseline conditions for CFB combustion with air firing, both without CO_2 capture and with a novel high-temperature CO_2 capture and sorbent regeneration process. Then, CFB-based concepts, employing an oxygen/flue gas mixture as the oxidizing agent, will be studied to determine what operating conditions and gas clean-up processes are most economical. The CO_2 concentration in the flue gas can be greatly increased by using oxygen instead of air for combustion.

In the second case, indirect combustion of coal, also known as chemical looping, will be evaluated. In chemical looping, synthesis gas (a mixture of CO and H_2) reduces a solid transition metal oxide to a lower oxidation state in a fluidized bed reactor with the production of water and CO_2. The off gas stream is cooled to condense water and produce a pure CO_2 stream for sequestration. The reduced metal containing solid is transferred to a second fluidized bed reactor, where it is reoxidized with air. This exothermic reaction heats the oxygen-depleted air, which is sent to power production.

Comparisons will be made with the Integrated Gasification Combined Cycle (IGCC) cases that have already been evaluated by Parsons Energy and Chemical Group. In this way, important features that can improve plant operations by utilizing oxygen firing will be explored, identified, and included in plant designs.

Greenhouse Gas Emissions Control by Oxygen Firing in Circulating Fluidized Bed Boilers

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Primary Project Goal

The overall project goal is to conduct economic evaluations of the recovery of carbon dioxide using a newly constructed CFB combustor while burning coal, petroleum coke, or biomass fuel with a mixture of oxygen and recycled flue gas, instead of air.

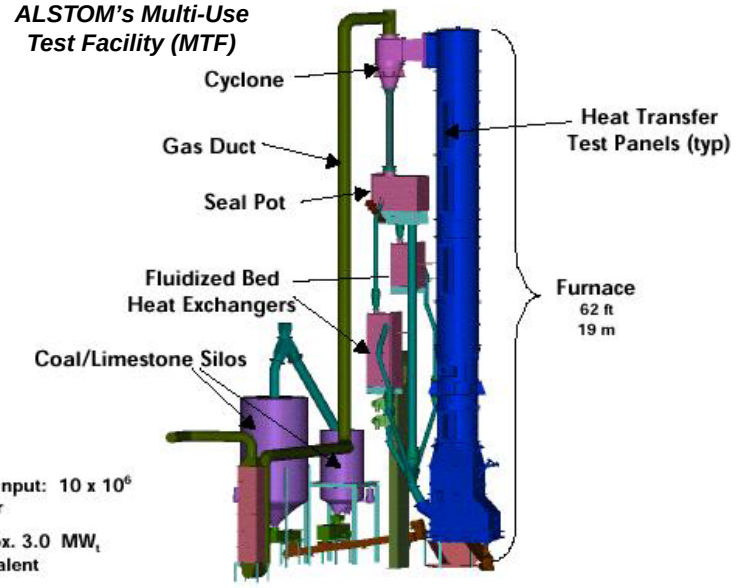
Objectives

- The Phase I objective is to determine which of the new concepts in a CFB are technically feasible and have the potential of reducing the target cost of carbon avoided.
- Petroleum coke and coal samples will be combustion tested in a 4-inch Fluid Bed Combustion reactor to determine their gaseous (NO_x, SO_2, CO) and unburned carbon emissions and ash agglomeration/sintering potentials during combustion in oxygen-rich environments.
- The Phase II objective is to generate a refined technical and economic evaluation of the most promising concept for reducing CO_2 mitigation costs (based on recommendations from Phase I), based on data from proof-of-concept testing of the most promising concept.

Accomplishments

The performance analysis of the base case (Air-Fired) CFB has been completed. Key results included plant-efficiency, equipment costs, cost of electricity, and CO_2 mitigation costs. Work has been initiated on design/performance analyses of:

- Three advanced O_2-fired CFB concepts
- One high temperature carbonate regeneration process
- One chemical looping concept
- Two IGCC cases (one base case without CO_2 capture and one with a water-gas shift reactor to capture CO_2).



Coal and petroleum coke samples have been acquired, analyzed, and prepared; the modification of the 4-inch FBC is underway.

Benefits

The results from this project will provide the power industry with concrete data concerning greenhouse gas emissions control by oxygen firing in circulating fluidized bed boilers. The comparison of the several different technologies will target the most economical gas clean-up configuration.